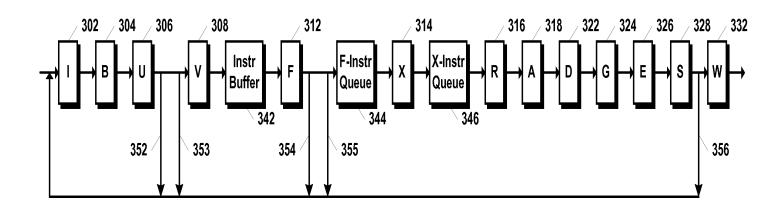


FIG. 3



Processor Pipeline Stages

300

Replacement Sheet

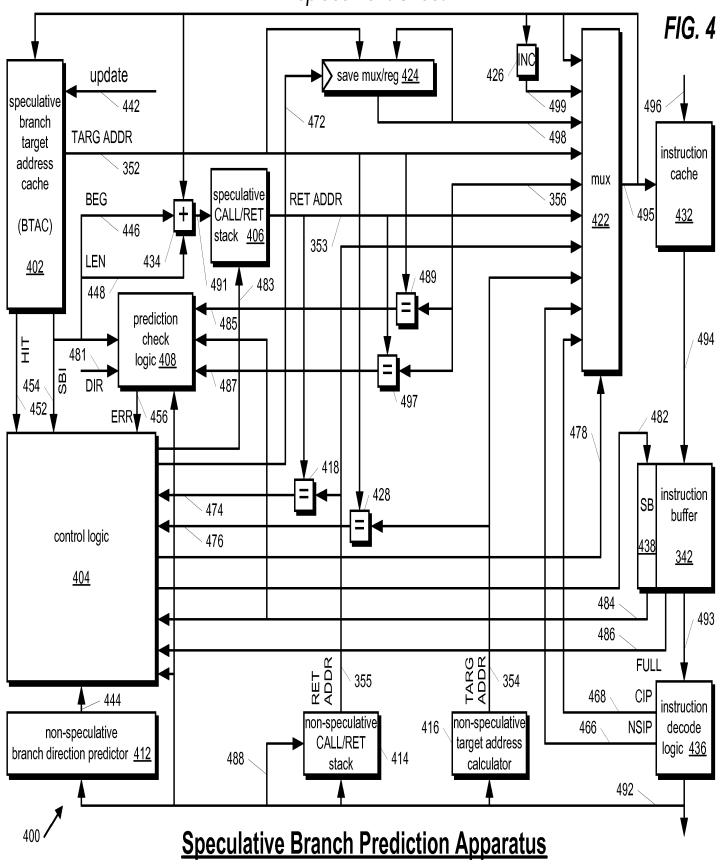
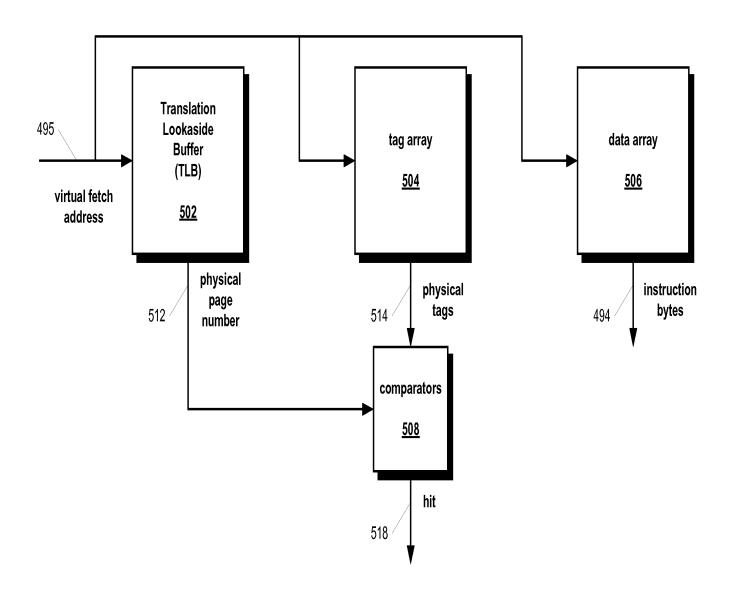


FIG. 5



432

Instruction Cache

FIG. 6

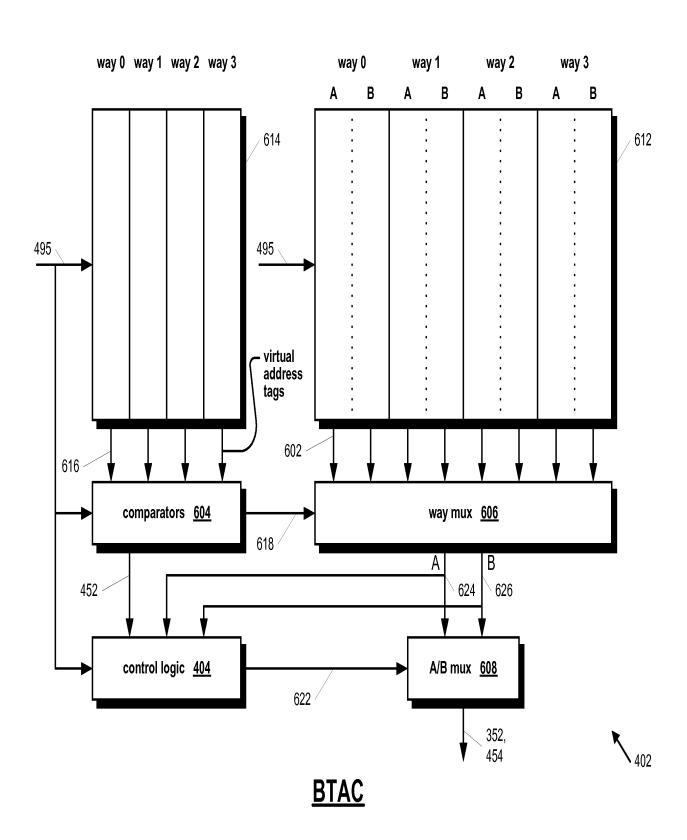
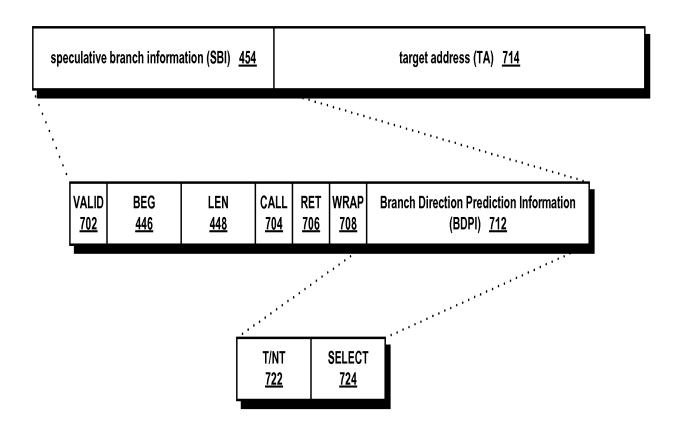
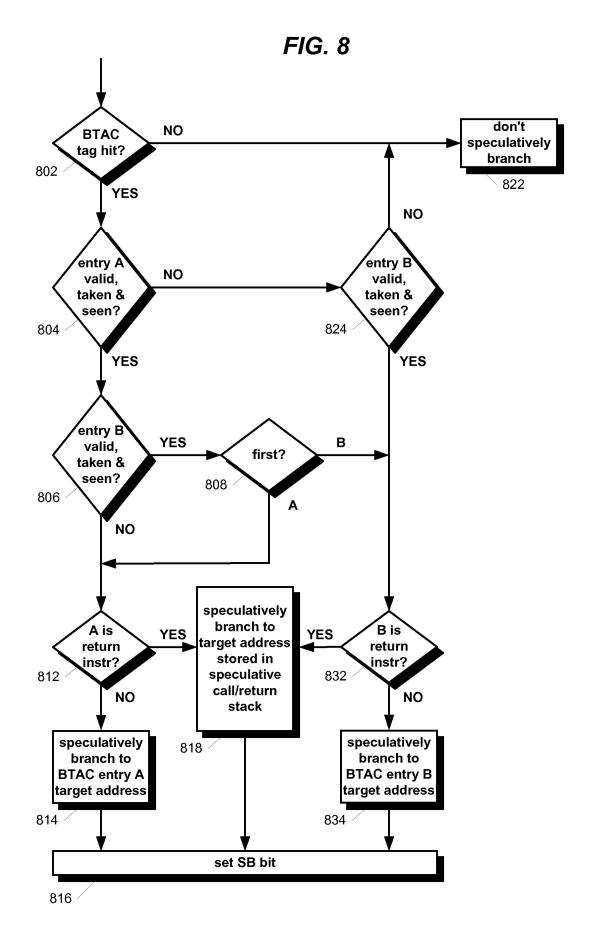


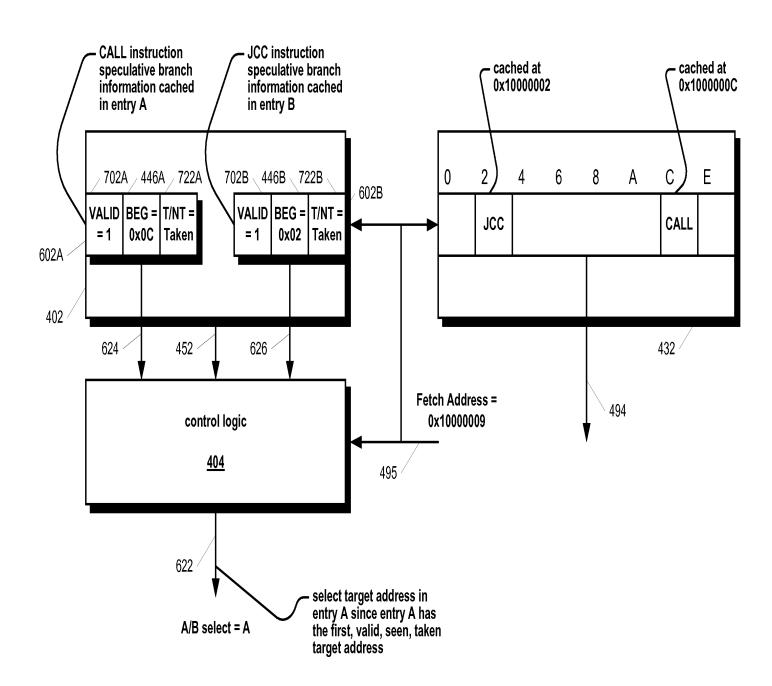
FIG. 7



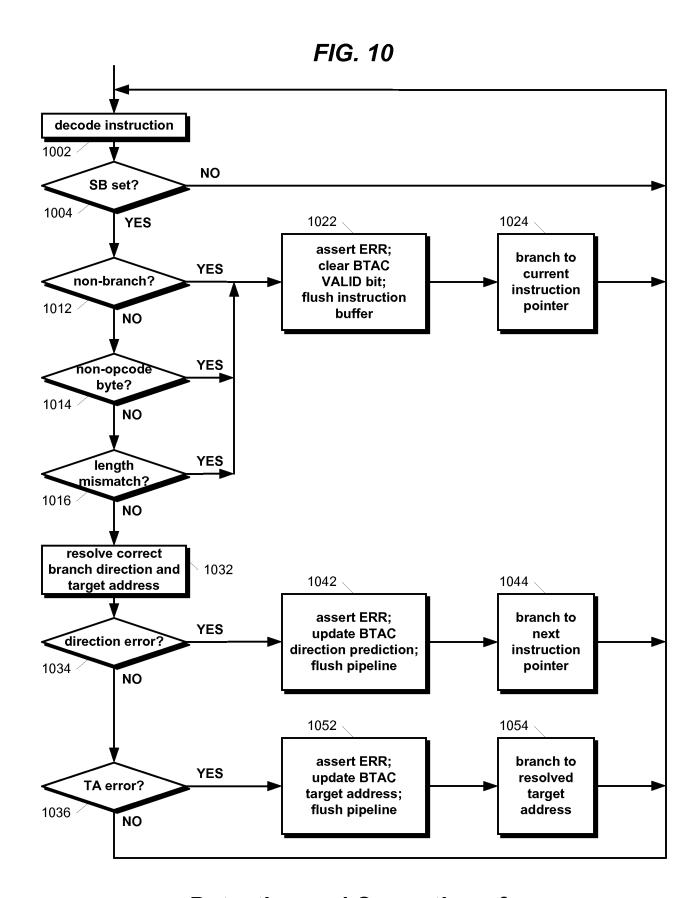


Speculative Branching Operation

FIG. 9



Target Address Selection Example



<u>Detection and Correction of</u> <u>Speculative Branch Misprediction</u>

FIG. 11

Previous Code Sequence:

0x00000010 JMP 0x00001234

. . .

Current Code Sequence:

0x00000010 ADD ;address 0x00000010 hits in BTAC generating a TA value of 0x00001234

. . .

0x00001234 SUB 0x00001236 INC

clock →	1	2	3	4	5	6	7
I-stage	ADD	X	X	SUB	INC	X	ADD
B-stage		ADD	X	X	SUB	X	X
U-stage			ADD	X	X	X	X
V-stage				ADD	X	X	X
F-stage					ADD	Х	X

Cycle 1 = BTAC and I-cache access cycle

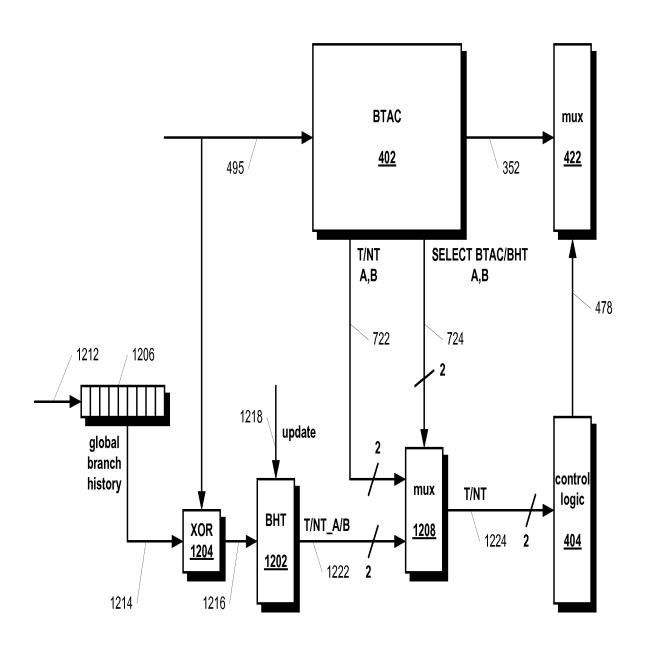
Cycle 4 = speculative branch cycle

Cycle 5 = speculative branch error detection cycle

Cycle 6 = BTAC invalidate cycle

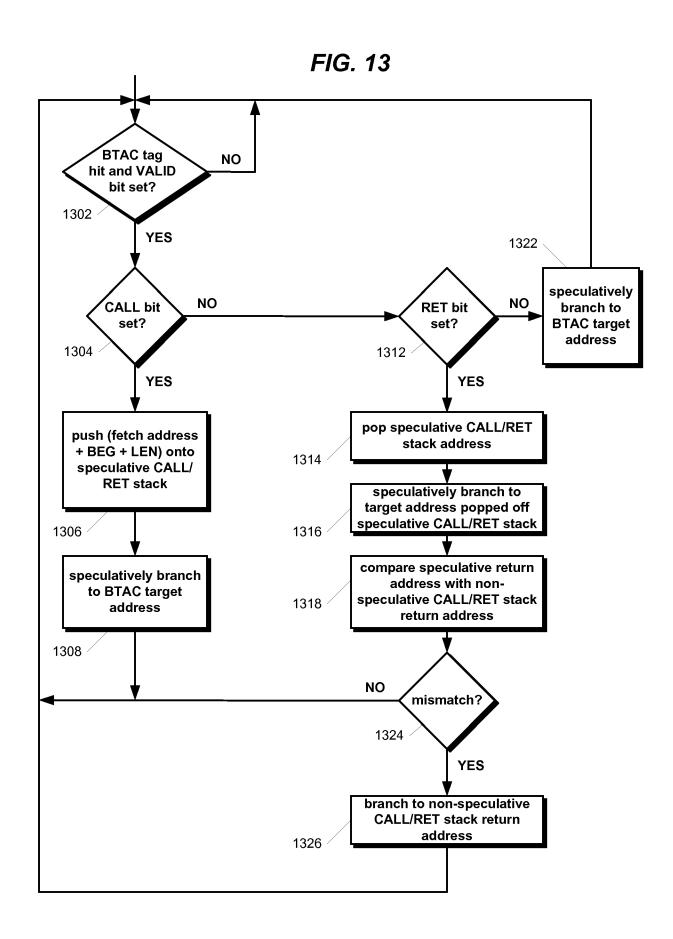
Cycle 7 = speculative branch error correction cycle

FIG. 12



1200

Hybrid Speculative Branch Direction Predictor



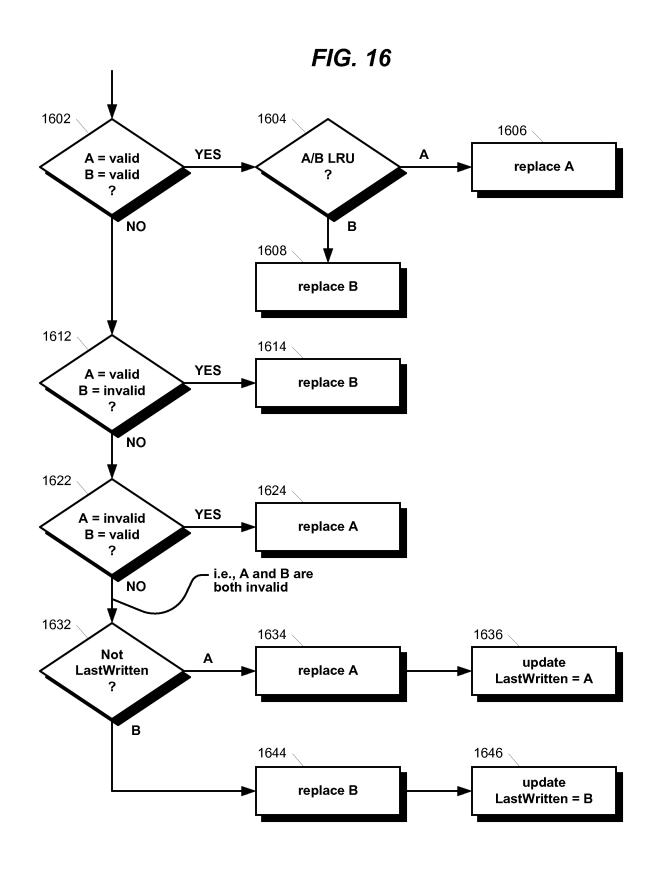
Dual CALL/RET Stack Operation

FIG. 14 decode instruction and generate instruction type and non-speculative branch predictions 1402 / YES NO NO direction target conditional? mismatch? mismatch? 1404 1412 1428 NO **YES** YES branch to nonnon-**TAKEN** speculative speculative target prediction? address 1432 1414 NOT **TAKEN** branch to next **DONE** sequential 1416 instruction pointer YES NO target RET? mismatch? 1406 1418 NO **YES** branch to nonspeculative return 1422 address YES NO target PC-relative? mismatch? 1408 1424 NO YES branch to nonspeculative target 1426 address

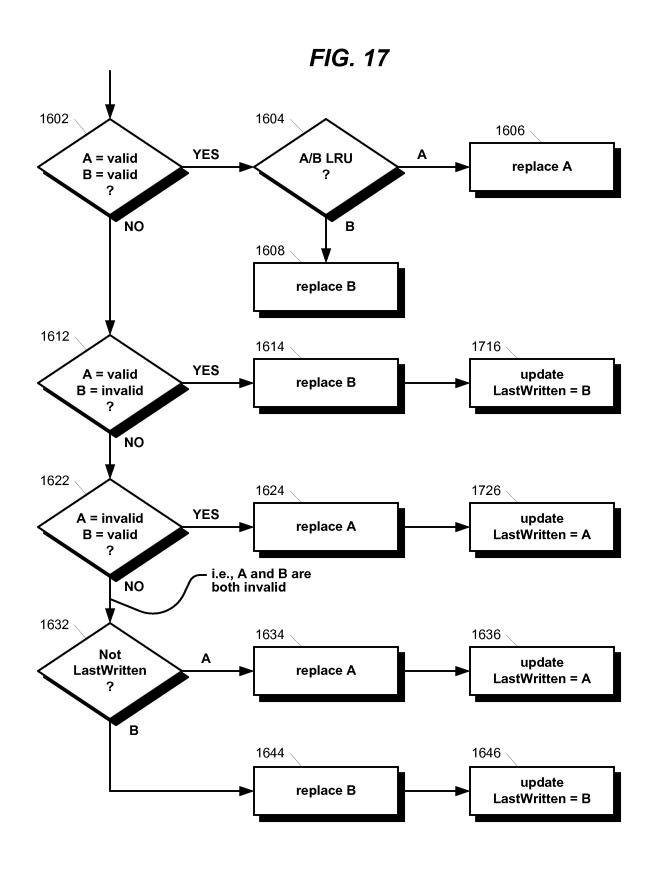
Selective Override of BTAC Prediction Operation

FIG. 15 include VALID bits -442 1514 495 A/B entry entry mux В LRU Α update IP <u>1506</u> <u>602A</u> <u>602B</u> <u>1504</u> 1512 612 624 **√** 626 ∕ 1516 control logic <u>404</u> LastWritten <u>1502</u> shared globally by all BTAC entries

BTAC A/B Replacement Apparatus

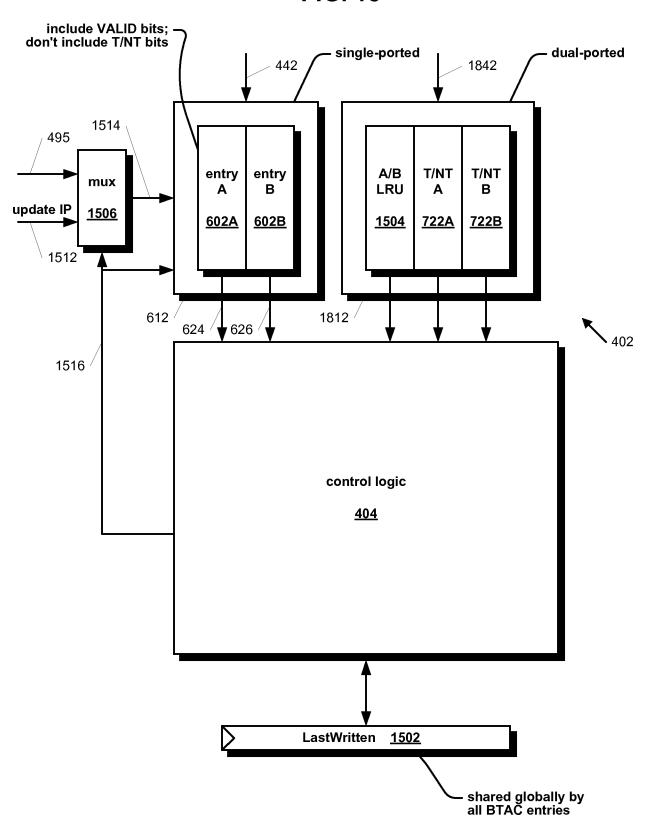


A/B Entry Replacement Method

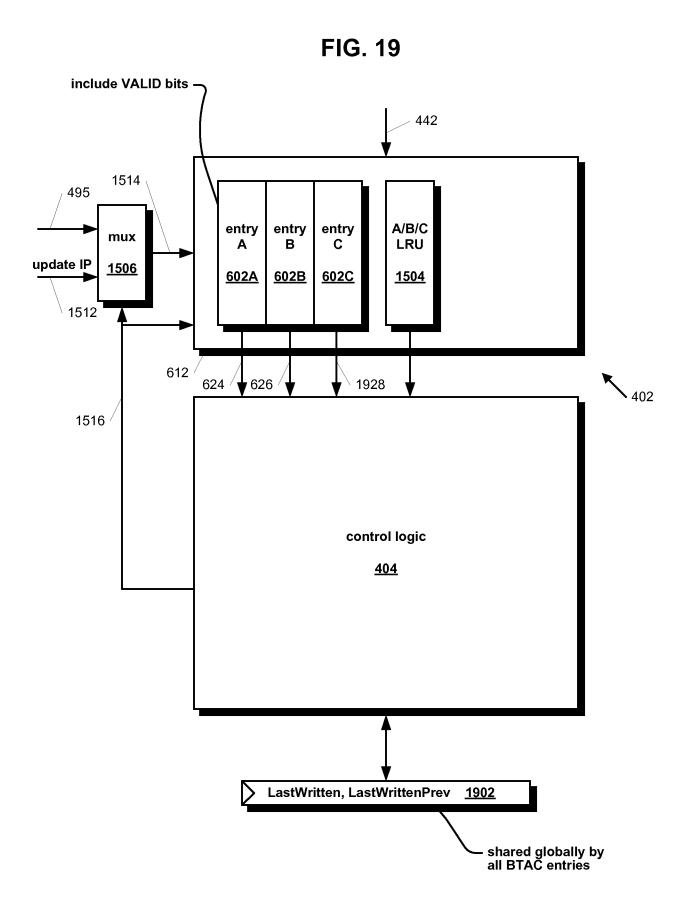


A/B Entry Replacement Method (Alt. Embodiment)

FIG. 18



BTAC A/B Replacement Apparatus (Alt. Embodiment)



BTAC A/B/C Replacement Apparatus

New Sheet

FIG. 20

